Claims

[c1] 1.A method for centrifugally separating a composite fluid into at least two of the component fluid parts thereof, said method comprising

receiving a composite fluid from a fluid source in a separation layer having a fluid receiving area adjacent an axis of rotation, said separation layer having:

a fluid inlet channel having an inlet channel height;

a circumferential fluid separation channel, said separation channel having a proximal end and a distal end; and,

a first separated fluid outlet channel having a first height;

a second separated fluid outlet channel having a second height, said second outlet channel being adjacent said distal end of said separation channel and said first outlet channel being proximal from said second channel, wherein said second height is less than said first height and said first height is less than said inlet channel height;

placing said inlet channel in fluid communication with said fluid receiving area; and

placing said circumferential separation channel in fluid

communication with said fluid inlet channel adjacent said proximal end of said separation channel and with each of said separated fluid outlet channels; and placing at least one separated fluid outlet channels in fluid communication with a corresponding separated component fluid receiver; and delivering at least one separated fluid component to a separated component fluid receiver.

[c2]   2. A method according to Claim 1 in which the relation-ship of the respective inlet and outlet positions of said inlet and said at least one separated fluid outlet channels to each other provides a fluid pressure imbalance.

[c3]   3. A method according to Claim 1 further comprising placing the respective inlet and outlet positions of said inlet and said at least one separated fluid outlet channels to provide a fluid pressure imbalance which provides fluid flow control by driving the flow of a composite fluid and at least one component thereof forward from the re-ceiving area, respectively through the inlet, circumferen-tial and at least one outlet channels.

[c4]   4.A method according to Claim 1 further comprising placing the respective inlet and outlet positions of said inlet and said at least one separated fluid outlet channels to each other to provide a fluid pressure imbalance for

respective fluids flowing through the respective inlet and at least one outlet channels, and is defined as:

$$\rho_1 g_1 h_1 > \rho_2 g_2 h_2;$$

wherein the first position, h_1, represents the relative radial height of the inlet channel, and the second position, h_2, represents the relative radial height of the first outlet channel, wherein g_1 and g_2 are centrifugal acceleration values and ρ_1 represents the density of the fluid in the inlet channel and ρ_2 represents the density of the fluid in the least one outlet channel.

[c5]   5. A method according to Claim 1 wherein the inlet position of the inlet channel is designated as h_1 and, wherein the outlet position of the first outlet channel is h_2, and the outlet position of the second outlet channel is h_3, and wherein g_1, g_2 and g_3 are centrifugal values, and ρ_1 represents the density of the fluid in the fluid inlet channel, ρ_2 represents the density of the fluid in the first outlet channel, and ρ_3 represents the density of the fluid in the second outlet channel, and whereby these structural values are related to each other such that the inlet channel fluid dynamic pressure, $\rho_1 g_1 h_1$, is greater than either of the two outlet fluid dynamic pressures, $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, as in:

$$\rho_1 g_1 h_1 > \rho_2 g_2 h_2 \text{ or, } \rho_1 g_1 h_1 > \rho_3 g_3 h_3;$$

so that fluid will flow from the fluid receiving area

through the respective first and second outlet channels.

[c6] 6.A method according to Claim 5 wherein the ρgh values may be incrementally summed such that: $\Sigma(\rho gh)_1 > \Sigma(\rho gh)_2$, or, $\Sigma(\rho gh)_1 > \Sigma(\rho gh)_3$.

[c7] 7.A method according to Claim 5 wherein the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of the inlet composite fluid to be separated, whereas, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of respective first and second separated fluid components.

[c8] 8.A method according to Claim 5 wherein the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of the inlet composite fluid to be separated, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of respective first and second separated fluid components, and $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$ equalize with each other.

[c9] 9.A method according to Claim 5 wherein the composite fluid to be separated is blood and the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of a whole blood com-

posite fluid, whereas, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of respective separated blood components.

[c10]　10. A method according to Claim 5 wherein the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of the inlet composite fluid to be separated, whereas, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of respective first and second separated fluid components; and the second ρ value in $\rho_2 g_2 h_2$ includes first and second elements from the respective first and second separated fluid components, such that $\rho_2 g_2 h_2$ is the sum of $\rho_{1stcomponent} g_{1stcomponent} (h_2 - h_i)$ and $\rho_{2ndcomponent} g_{2ndcomponent} h_i$; wherein h_i is the height of the interface between the first and second separated fluid components.

[c11]　11. A method according to Claim 10 wherein the composite fluid to be separated is blood and the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of whole blood, whereas, the respective first and second separated fluid ρ values, appearing in $\rho_{1stcomponent} g_{1stcomponent} (h_2 - h_i)$ and $\rho_{2ndcomponent} g_{2ndcomponent} h_i$; represent the densities of the separated components, plasma and red blood cells (RBCs), respectively.

[c12] 12.A method according to Claim 1 further comprising selecting the respective first and second lengths of said first and second separated fluid outlet channels to each other to provide a substantial fluid pressure balance for respective fluids flowing therethrough.

[c13] 13.A method according to Claim 1 further comprising selecting the respective first and second lengths of said first and second separated fluid outlet channels to each other to provide a substantial fluid pressure balance for respective fluids flowing through the respective first and second outlet channels, and is defined such that it provides fluid flow control of the interface of separated fluid components within the circumferential separation channel.

[c14] 14.A method according to Claim 1 further comprising selecting the respective first and second lengths of said first and second separated fluid outlet channels to each other to provide a substantial fluid pressure balance for respective fluids flowing through the respective first and second outlet channels, and is defined as:

$$\rho_2 g_2 h_2 = \rho_3 g_3 h3$$

wherein the first length of the first outlet channel is h_2, and the second length of the second outlet channel is h_3, wherein g is a gravitational acceleration value and ρ_2

represents the density of the fluid in the first outlet channel and ρ_3 represents the density of the fluid in the second outlet channel.

[c15] 15. A method according to Claim 14 wherein the ρgh values may be incrementally summed such that $\Sigma(\rho gh)_2 = \Sigma(\sigma gh)_3$.

[c16] 16. A method according to Claim 14 in which the composite fluid to be separated is blood and the first and second separated components are plasma and red blood cells (RBCs), respectively.

[c17] 17. A method according to Claim 14 in which the ρ_2 value in the $\rho_2 g_2 h_2$ term has two distinct components derived from a combination of separated fluid component terms such that $\rho_2 g_2 h_2$ is the sum of $\rho_{1stcomponent} g_{1stcomponent} (h_2 - h_i)$ and a $\rho_{2ndcomponent} g_{2ndcomponent} h_i$; whereby h_i is the height of the interface between the first and second separated fluids, and,

$$\rho_2 g_2 h_2 = \rho_{1stcomponent} g_{1stcomponent} (h_2 - h_i) + \rho_{2ndcomponent} g_{2ndcomponent} h_i = \rho_{2ndcomponent} g_{2ndcomponent} h_3 = \rho_3 g h_3 .$$

[c18] 18. A method according to Claim 14 in which the composite fluid to be separated is blood and the first and second separated components are plasma and red blood cells (RBCs); and wherein the ρ_2 value in the $\rho_2 g h_2$ term

has two distinct components derived from a combination of separated fluid component terms, thus having a plasma and an RBC component such that $\rho_2 g_2 h_2$ is the sum of $\rho_{plasma} g_{plasma} (h_2 - h_i)$ and a $\rho_{RBC} g_{RBC} h_i$ portion; wherein h_i is the height of the interface between the RBCs and the plasma, and,

$$\rho_2 g_2 h_2 = \rho_{plasma} g_{plasma} (h_2 - h_i) + \rho_{RBC} g_{RBC} h_i = \rho_{RBC} g_{RBC} h_3 = \rho_3 g_3 h_3 .$$

[c19] 19. A method according to Claim 14 wherein the inlet position of the inlet channel is designated as h_1 and wherein the first outlet position of the first outlet channel is h_2, and the second outlet position of the second outlet channel is h_3, wherein g_1, g_2 and g_3 are centrifugal values and ρ_1 represents the density of the fluid in the fluid inlet channel, ρ_2 represents the density of the fluid in the first outlet channel, and ρ_3 represents the density of the fluid in the second outlet channel and these values are related to each other such that the inlet fluid dynamic pressure, $\rho_1 g_1 h_1$, is greater than the either of the two outlet fluid dynamic pressures, $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, as in:

$$\rho_1 g_1 h_1 > \rho_2 g_2 h_2 \text{ or } \rho_3 g_3 h3$$

so that fluid will flow from the inlet toward the outlets.

[c20] 20. A method according to Claim 19 wherein the ρ values are different for each term in the relationship such that

the first ρ value, in $\rho_1 g_1 h_1$, is the density of the inlet composite fluid to be separated, whereas, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of the respective first and second separated fluid components.

[c21] 21. A method according to Claim 18 wherein the composite fluid to be separated is blood and the ρ values are different for each term in the relationship such that the first ρ value, in $\rho_1 g_1 h_1$, is the density of whole blood, whereas, the second and third ρ values, appearing in $\rho_2 g_2 h_2$ and $\rho_3 g_3 h_3$, represent the densities of the first and second separated components, plasma and red blood cells (RBCs).

[c22] 22. A method according to Claim 1 further comprising delivering the separated fluid component to at least one separated fluid outlet channel such that the separated fluid component retains kinetic energy to flow to the corresponding separated component fluid receiver.

[c23] 23. A method according to Claim 22 in which the kinetic energy is retained by action of a vortex pump configuration.

[c24] 24. A method according to Claim 1 further comprising providing a balance channel which is disposed in fluid

communication with the circumferential channel, said balance channel being between said proximal end of said circumferential channel and said first channel and having a geometry that counterbalances said first and second outlet channels, whereby said balance channel may provide a weight balance to said configuration relative to said inlet channel and the at least one outlet channel.

[c25] 25.A method for separating a composite fluid into at least two of the component parts thereof, the method comprising:

providing a rotor configuration having:

a rotor which includes

a composite fluid containment area;

a fluid inlet channel;

a peripheral fluid separation channel; and

first and second separated fluid outlet channels;

wherein said inlet channel is disposed in fluid communication with said fluid containment area; and wherein said peripheral separation channel is disposed in fluid communication with said fluid inlet channel and said first and second separated fluid outlet channels; and wherein said first and second separated fluid outlet channels are adapted to be disposed in fluid communication with discrete first and second separated component storage containers; and

whereby said inlet channel and said first and second separated fluid outlet channels also have respective inlet and first and second outlet heights wherein said heights are related to each other so as to provide a substantial fluid pressure flow control for respective composite and separated components flowing therethrough; and delivering a composite fluid to the composite fluid containment area of said rotor configuration; and rotating said rotor configuration to separate said composite fluid into its component parts.

[c26]   26.A method according to Claim 25, which further includes collecting said separated components.

[c27]   27.A method according to Claim 25, which further includes automatically driving the flow through said separation channel.

[c28]   28.A method according to Claim 25, which further includes automatically shutting off the flow through said separation channel.

[c29]   29.A method according to Claim 25, which further includes automatically readjusting the flow in and through said separation channel by automatically equalizing fluid pressure in the first and second separated fluid outlet channels.

[c30] 30. A method according to Claim 25, which further includes automatically capturing an intermediate phase component in said separation channel by automatically shutting off the flow out of said separation channel after collection of said first and second separated components when a there remains no more composite fluid to be separated.

[c31] 31. A method according to Claim 25, which further includes using a disposable rotor configuration.